Visualization of Hyperspectral Images Through Interactive Sections

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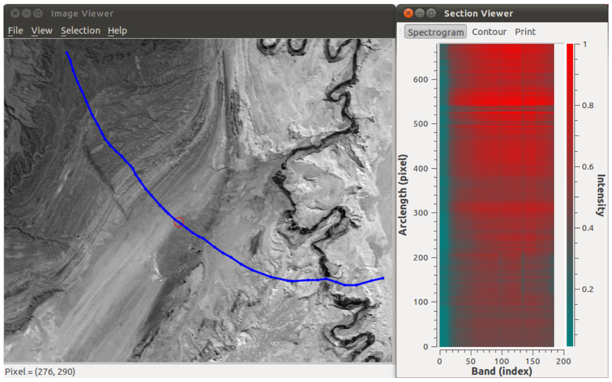

Introduction: The presented work consists of a novel method for visualizing hyperspectral images and an evaluation with expert users in the context of minerology. Advances in remote sensing and progress in scientific missions to collect data of the Earth, Moon and Mars are creating a need for useful visualization methods. In particular, hyperspectral images are challenging to visualize due to their high dimensionality, and the presented method addresses this by reducing the spatial data dimension to a path in the image and rendering a visualization of the spectra along this path.

Method: Each hyperspectral image consists of a set of images of the same scene taken at different wavelengths, which commonly described as an image stack or cube. Since the number of spectral measurements will typically vastly outnumber the number of colors that can be sensed by the human visual system, these images cannot be visualized directly. A variety of tools exist for spectral dimensionality reduction, often by algebraic manipulation of certain bands or decomposition of the entire spectrum into several representitive groups. Spatial dimensionality reduction techniques exist, but are limited to point sampling and statistics on simple regions of interest.

The presented work is a spatial dimensionality reduction technique that interactively visualizes the full spectrum along a path, which can be imagined as a piecewise-linear section through the image in the spatial domain. The user chooses a series of points in spatial coordinates to define the path, and the spectra at regular intervals of this path are sampled. This collection of spectra is then rendered as an image, where one dimension is the spectral band, one dimension is the arclength along the path, and the color is a mapping hyperspectral image intensities in a given band at a given arclength. The path and color map can be edited interactively, and a traditional point sampled spectrum is provided additionally. The views of the spatial domain and section visualization are linked to allow the user to track features across displays.

Implementation: The work is available as a cross-platform and open-source software package written in C++. Many image file formats are supported through use of the Geospatial Data Abstraction Library (GDAL). Qt 4 and Qt Widgets for Technical applications (Qwt) are used for the user interface. The sampling of spectra along the path is performed by parameterizing the curve by arclength and bilinearly resampling at a rate of one sample per pixel.

Results: The computational demands of curve editing, visualization and sampling were found to be practical for real-time applications, and the test data sets were found to be compatible with the GDAL library.

The tool was used in an informal evaluation by members of the Brown Department of Geology in the context of minerological applications. They found the tool to be generally useful and expect it to be used in the course of research. In the context of minerology, the general shape variation of thermal infrared spectra was found to be readily visualized with the tool. However, the benefits for near-infrared spectra were found to be fewer, due to the localization of the absorbtion bands. Several potential additions were suggested, including rendering the spectra relative to a given spectrum, supporting multiple paths, and overlaying an image that has been segmented by spectral dimension reduction methods.

Discussion: Due to the nature of hyperspectral images, there is no natural way of visualizing an entire dataset. Consequently, a variety of methods must be employed. The presented work aims to address the reduction of spatial domain, allowing visualization of the full spectrum at more than a single point. In addition to a variety of methods, there are many types of data and scenes that influence the efficacy of a tool. Hence, a variety of tools and an understanding of their relative strengths and weaknesses is necessary to address each scenario.

References

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